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Report No. L800-89

Aerojet-General CORPORATION

AZUSA, CALIFORNIA

INFORMAL REPORT OF PROGRESS

Copy No. 12

15 February 1954

TO: Office of Naval Research
Department of the Navy
Washington 25, D. C.

VIA: Bureau of Aeronautics Representative
Aerojet-General Corporation
6352 N. Irwindale
Azusa, California

SUBJECT: Research, Development, and Testing of Underwater Propulsion Devices

CONTRACT: N6ori-10, Task Order I
Project NR 097 003

PERIOD COVERED: 1 January through 31 January 1954

This informal monthly progress report is submitted in partial fulfillment of the contract.

M. S.

362
2 copies

AEROJET-GENERAL CORPORATION

C. A. Gongwer

C. A. Gongwer, Manager
Underwater Engine Division

NOTE: The information contained herein is regarded as preliminary and subject to further checking, verification, and analysis.

3091610

Receipt acknowledged

DEC 15 1954

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I. HYDRODUCTOR INVESTIGATIONS IN THE STATIC-TEST PIT

Because it has been established that the symmetry of the entering condensing jet is not as critical as was previously believed, a program has been undertaken to determine whether the scoop design can be simplified. In the present design 30 separate passages empty into the condensing chamber. If the operation would permit modification so that the water could be injected in an almost continuous, circumferential sheet, fabrication would be simplified. A new scoop section with only three piers was constructed and is now being tested. Some static test runs have been made, with indications that performance at least equal to that of the original design can be achieved. It is planned to investigate several alternative designs and select the best configuration on the basis of performance and fabrication.

II. HYDRODUCTOR INVESTIGATIONS ON THE ROTATING BOOM

A. A simulated hydroductor model (Figures 1 and 2) used in conjunction with the steam accumulator system on the rotating boom was tested during the current report period, and satisfactory performance was obtained.

B. The initial effort on the program was directed toward investigation of the starting characteristics of the motor. With this object, early test work was performed with the motor starting in a freely flooded condition. This proved unsatisfactory, as it was impossible to establish condensing operation or proper flow in the condensing chamber. In the next phase of the program effort was concentrated on sealing the condensing water scoops until proper steam flow could be established from the combustion chamber. After a satisfactory sealing technique had been worked out, further testing resulted in successful operation. The performances of the freely flooded hydroductor and the initially sealed model may be compared by reference to Figures 3 and 4. Drag, combustion chamber pressure (P_c), total head at the condensing water scoop outlet (P_{mv}), and condensing chamber pressure (P_{COND}) were measured for these models. The drag readings in both instances include strut tare.

C. Figure 4 shows that proper condensing operation started upon removal of the scoop closure. This figure also indicates that the flow through the condensing chamber is stable once proper operation is established, because the condensing chamber vacuum does not collapse as the steam flow decreases. It was originally hoped that this stable condition could be achieved at the start of the run without the necessity of resorting to scoop closures.

D. Photographic studies of the hydroductor model in operation showed cavitation from the leading edge of the water scoop, indicating prediffusion in front of the scoop passage. In order to eliminate cavitation the scoop inlet diameter was reduced without altering the main scoop passage. The revised model has been completed and will be mounted on the rotating boom for immediate testing. Should cavitation persist on the reworked model a redesign of the scoop section may become necessary.

III. EXTERNALLY CONDENSING HYDRODUCTOR

A series of test nozzles of annular design have been made. It is planned to use these in the small-scale pressure tank to determine thrust coefficients for this type of nozzle.

IV. SOLID-PROPELLANT GAS-TURBINE POWER PLANT

A. Primary emphasis was placed on turbine testing because firing the solid-propellant gas generator alone presents no particular difficulty. Turbine Test No. T-21, conducted on 5 January 1954, was satisfactory for the first 40 sec, but had to be prematurely halted when a bearing in the turbine seized. The operating speed of the turbine was 60,200 rpm. This ball bearing on the turbine shaft must carry the combined thrust load due to the 460-psia back pressure and the seal load resulting from high water pressure supplied to the water-lubricated, carbon-sleeve bearing at the turbine-wheel end of the shaft. This thrust load may be as high as 500 lb. In order to reduce the magnitude of the bearing thrust load, the seal configuration was modified to permit the use of a smaller seal. This design reduced the thrust load to less than 400 lb. In addition, the design was further modified so that the thrust load would be shared equally by a bearing in the gearbox.

B. In the second turbine test, T-23, the bearings with load distribution modified as described above performed satisfactorily. However, this run had to be stopped prematurely because of failure of a lightly loaded bearing in the gearbox. The exact cause of the failure has not been ascertained, but the lubrication system and oil drain system are being rechecked to determine whether both are adequate for operation at 60 to 62,000 rpm. Turbine testing will continue with the modified bearing setup, which is expected to operate satisfactorily at the 30-hp level and 62,000-rpm turbine speed.

C. One gas generator test, G-22, was conducted on a new batch of propellant. Combustion was smooth for the entire 2 min. A very slight progressivity in chamber pressure was noted during the run, but it will be of no significance with the type of turbine speed controller planned for this power plant. The controller will vary chamber pressure according to the load demand placed on the turbine. If, for some reason, a very flat pressure vs time characteristic is desired, this can be attained with a minimum of grain modification. Figure 5 is a plot of the pressure vs time record from Run G-22. Tabulated in the upper right-hand corner of Figure 5 are data pertaining to this run. The calculated weight flow coefficient, C_W, was 0.00835 lb/lb-sec for the test, and the theoretical value determined for AN-2091 propellant is 0.00820 lb/lb-sec. This is indicative of a slightly lower gas temperature, probably resulting from heat transfer to the metal parts. A shielded thermocouple is being installed in the chamber end to record the actual gas temperature of each run, which will augment the data normally recorded.

D. Analysis is continuing on the turbine speed controller in order to determine the effect of controller parameters on the entire propulsion system. Such study will make possible the design of a better controller and tend to limit the development required.

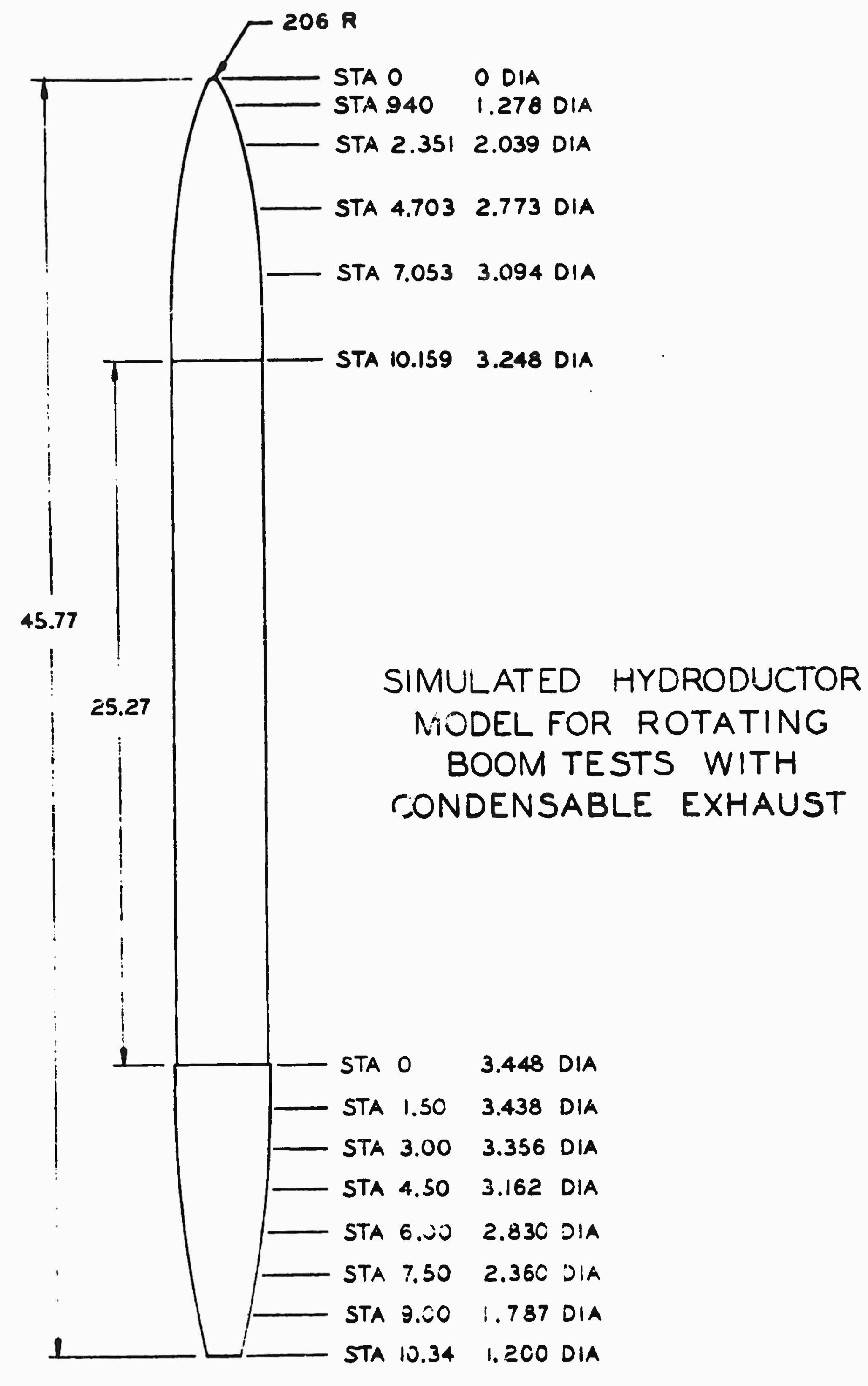
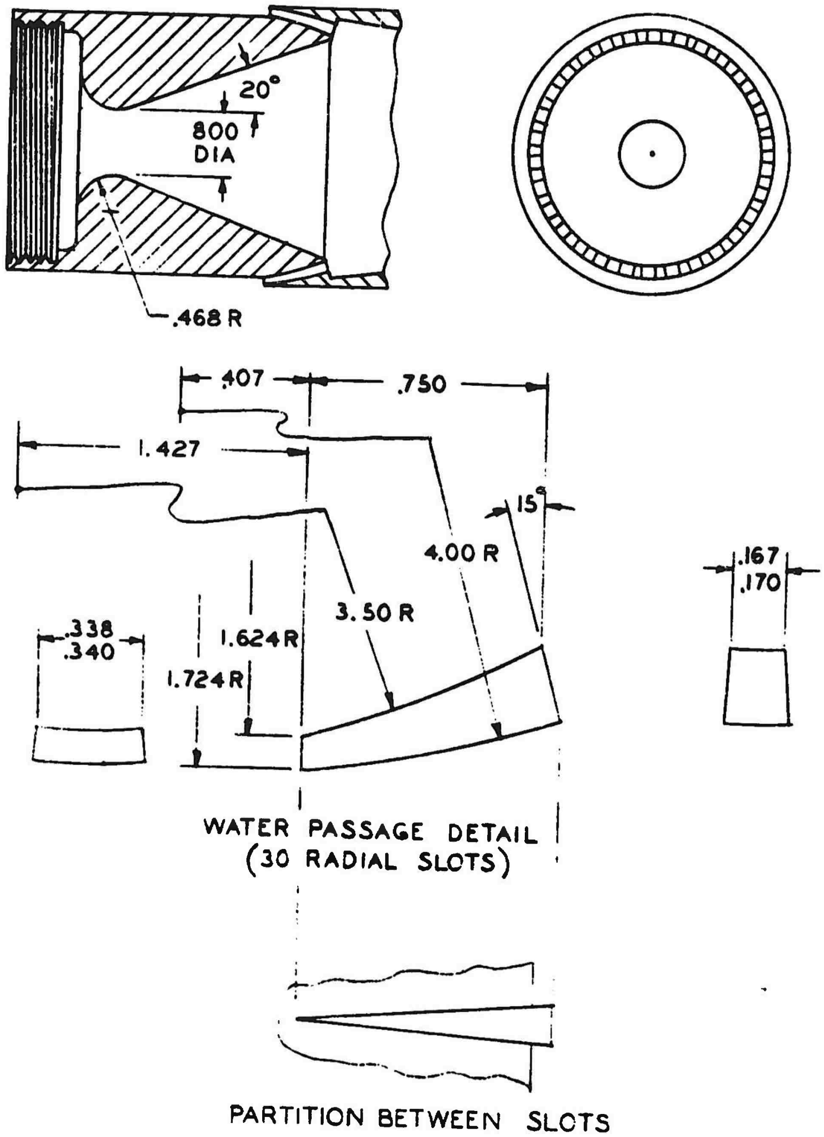

206 R
STA 0 0 DIA
STA .940 1.278 DIA
STA 2.351 2.039 DIA
STA 4.703 2.773 DIA
STA 7.053 3.094 DIA
STA 10.159 3.248 DIA
45.77
25.27
SIMULATED HYDRODUCTOR MODEL FOR ROTATING BOOM TESTS WITH CONDENSABLE EXHAUST
STA 0 3.448 DIA
STA 1.50 3.438 DIA
STA 3.00 3.356 DIA
STA 4.50 3.162 DIA
STA 6.00 2.830 DIA
STA 7.50 2.360 DIA
STA 9.00 1.787 DIA
STA 10.34 1.200 DIA

Figure 1



HYDRODUCTOR STEAM NOZZLE
AND SCOOP PASSAGE DETAILS

Figure 2

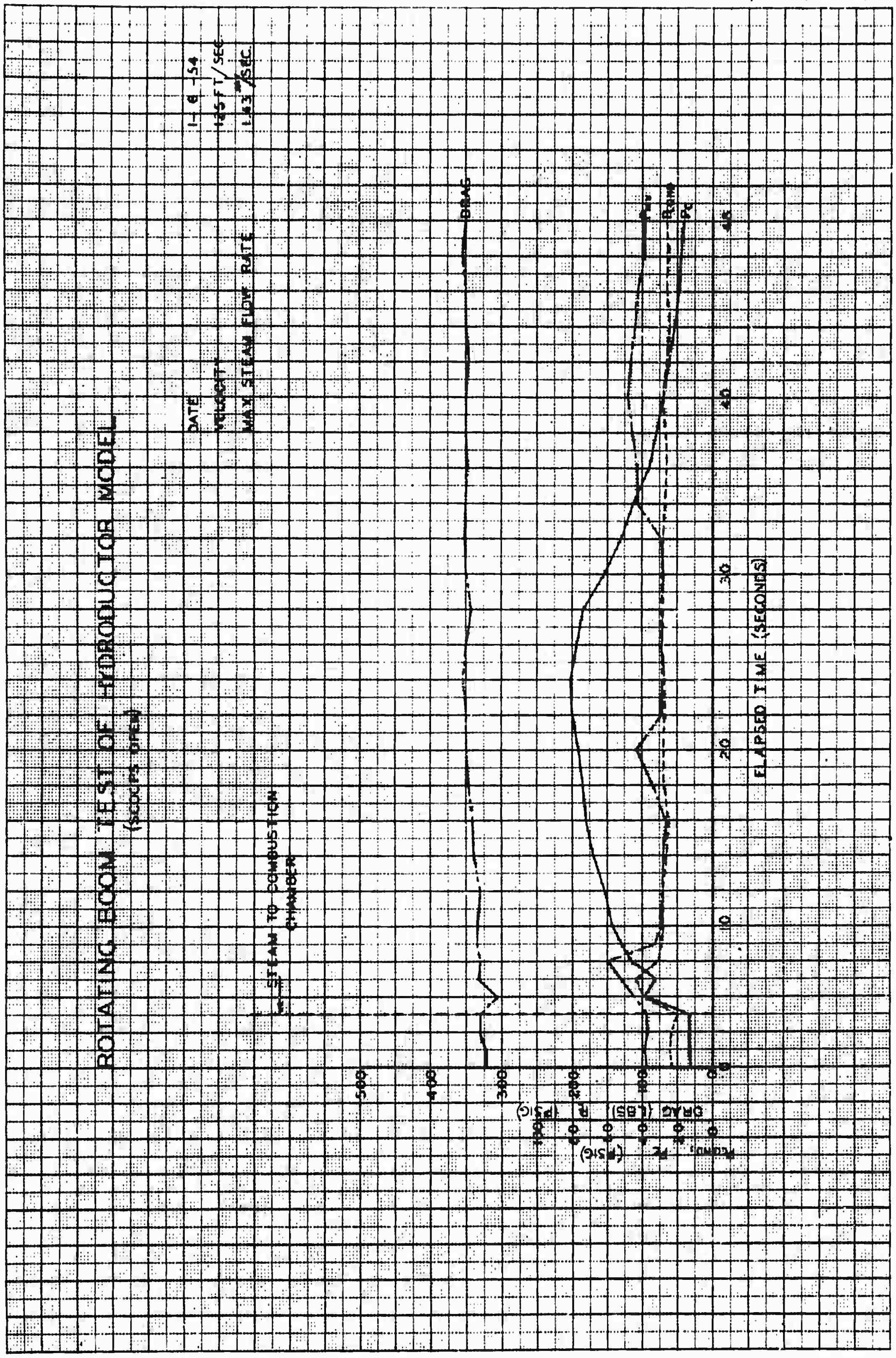

ROTATING BOOM TEST OF HYDRODUCTOR MODEL
(SCOOPS OPEN)
DATE 1-8-54
VELOCITY 125 FT/SEC
MAX STEAM FLOW RATE 1.63 #/SEC
STEAM TO COMBUSTION CHAMBER
DRAG
0
10
20
30
40
45
ELAPSED TIME (SECONDS)
500
400
300
200
100
0
DRAG (LBS)
100
80
60
40
20
0

Figure 3

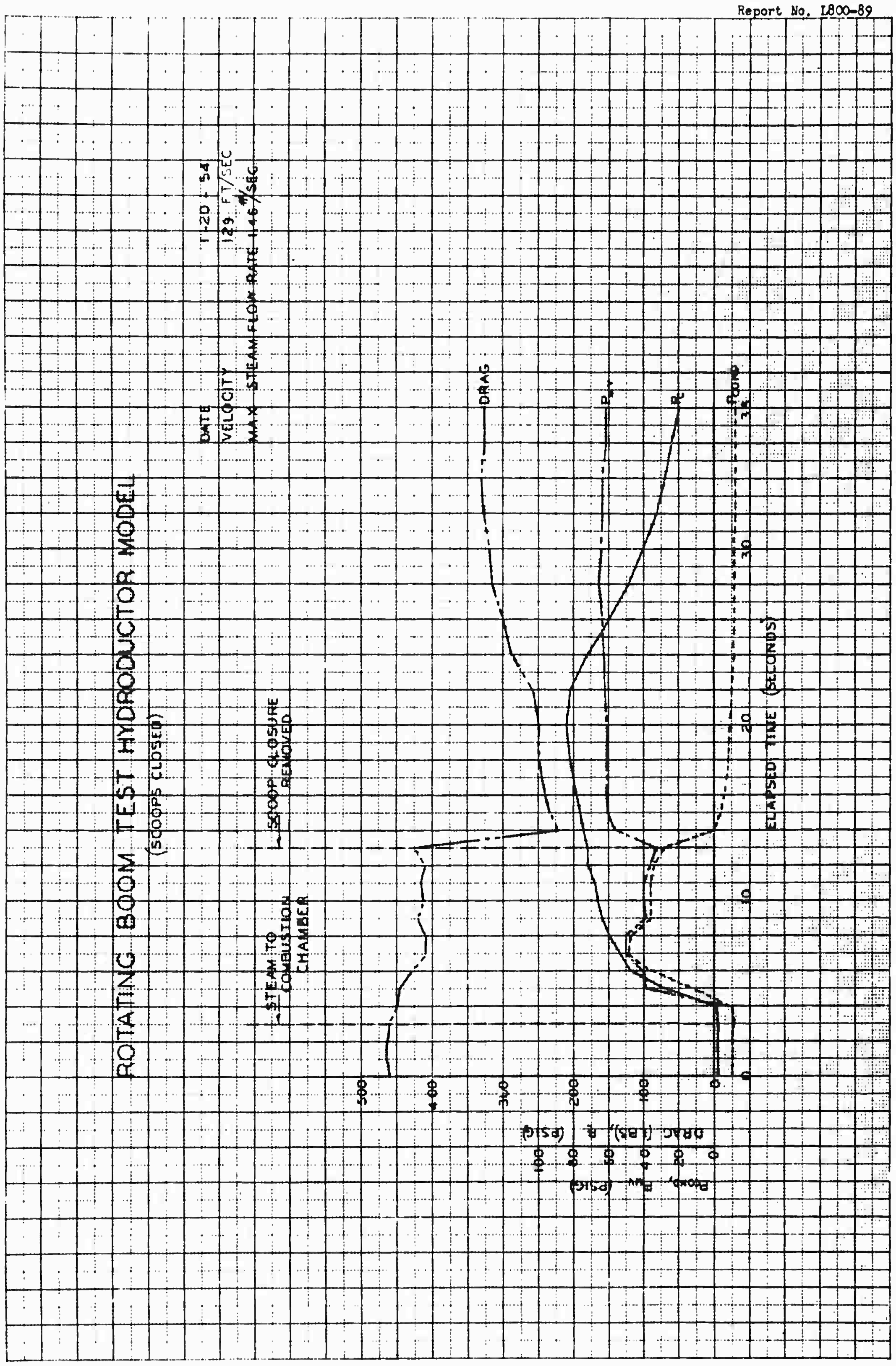

ROTATING BOOM TEST HYDRODUCTOR MODEL
(SCOOPS CLOSED)
DATE 1-20-54
VELOCITY 129 FT/SEC
MAX STEAM FLOW RATE 1.46 #/SEC
STEAM TO COMBUSTION CHAMBER
SCOOP CLOSURE REMOVED
DRAG
P_av
P_c
P_cond
ELAPSED TIME (SECONDS)
0
10
20
30
500
400
300
200
100
0
DRAG (LBS), P_c (PSIG)
100
80
60
40
20
0
P_cond, P_av (PSIG)

Figure 4

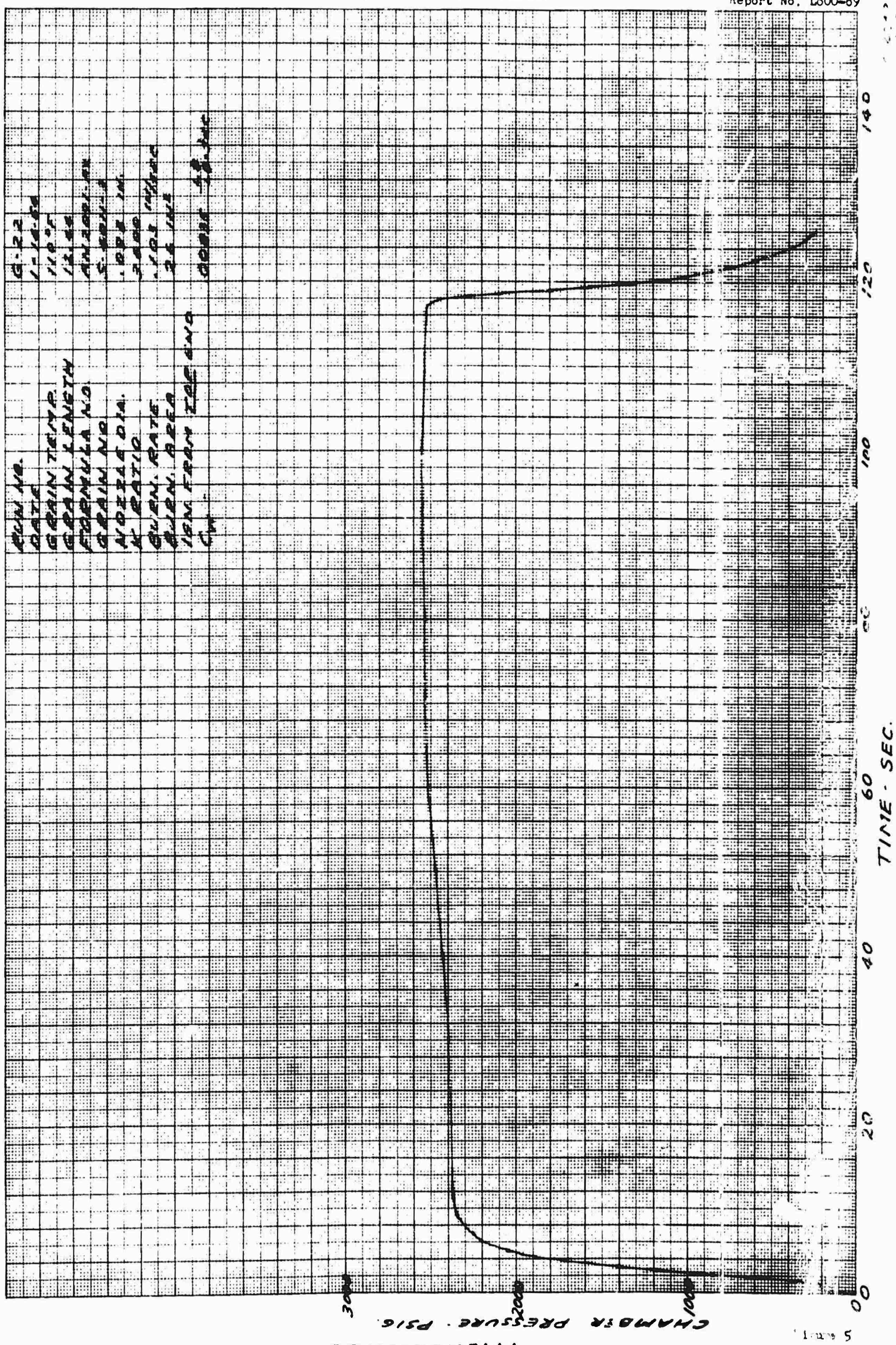

TIME - SEC.
0
20
40
60
80
100
120
140
CHAMBER PRESSURE - PSIG.
1000
2000
3000

Figure 5